Bulletin Penelitian Kesehatan
(Health Studies in Indonesia)

Vol. XII No. 1
1984

STUDIES OF FILARIASIS IN KEBAN AGUNG AND GUNUNG AGUNG VILLAGES IN SOUTH BENGKULU, SUMATERA, INDONESIA IV:

Ecological and seasonal aspect of four *Mansonia* species *

Sudomo M.[1], Suwarto[1] and Lim Boo Liat[2]

ABSTRACT

Dalam penelitian mengenai nyamuk Mansonia spp. di desa Gunung Agung dan Keban Agung, Bengkulu Selatan ternyata nyamuk Ma. bonneae dan Ma. annulata lebih banyak ditangkap daripada Ma. dives dan Ma. uniformis. Habitat nyamuk ini adalah rawa-rawa buatan atau daerah-daerah pinggiran hutan. Secara umum tidak ada hubungan antara curah hujan dan kepadatan nyamuk jenis Mansonia spp. Dari penelitian distribusi vertikal ternyata Ma. bonneae dan Ma. dives lebih banyak tertangkap di tempat yang tinggi sedangkan Ma. uniformis dan Ma. annulata di tempat yang rendah.

INTRODUCTION

Studies on brugian filariasis of two villages in South Bengkulu, Sumatera revealed that the human filariasis infections were nocturnally periodic, and that *Mansonia* mosquitoes were the main vectors of the parasite (Suzuki et al. 1981). Further studies on the *Mansonia* vectors in the areas were continued for a 24 month period to reveal (1) seasonal density variations, (2) seasonal parous rate variation, (3) nocturnal biting activities, and (4) larval habitats.

MATERIALS AND METHODS

The study areas (Fig. 1), and the procedures on monthly nocturnal collections of landing mosquitoes from indoors and outdoors have been documented by Sudomo et al. (1983). To assess seasonal variations of these mosquitoes, monthly catches, expressed in mean number mosquito per man/hour were plotted against the monthly rainfall. Parous rates of four *Mansonia* species were determined by ovarian dissection of most of the mosquitoes caught.

All night collection of landing mosquitoes were made in the two villages from 18.00 to 06.00 hours. The collection of mosquitoes was made at 3 indoor and 3 for outdoor locations at 4 hourly intervals for each shift of 6 mosquito scouts. This was repeated four times in each area.

The sampling of *Mansonia* larvae followed the method of Gillett (1946). Handfuls of aquatic vegetation were uprooted, and large enamel basin thrust beneath the roots. If larvae are present, they swim sluggishly about the water feeling for a new root, and are thus trapped in the basin, which is removed, and the water then decanted off very slowly. The larvae collected were kept in the field laboratory to be reared to adult to confirm the species. Identification of larvae and adults was based on the key by Wharton (1962).

Two tree ladders built of bamboo stems nailed to tall trees, one each at Keban Agung and Gunung Agung. The height of each ladder was 18 meters. Three platforms at heights of 5, 10, and 15 meters were constructed for each ladder. One collector was used at each elevation plus one at

* This study is supported by filariasis component of the UNDP/World Bank/WHO special programme for Research and Training in Tropical Diseases.

1. Health Ecology Research Centre, National Institute of Health Research and Development, P.O. Box 226, Jakarta, Indonesia.

2. WHO, Vector Biology and Control Research Unit-II, P.O. Box 302, Jakarta, Indonesia.

ground level. Landing catches were made from 18.00–22.00 hours twice a month over a 12 month period.

For statistical analysis of the field data the correlation coefficient, Chi-square test, and an analysis of variance were used.

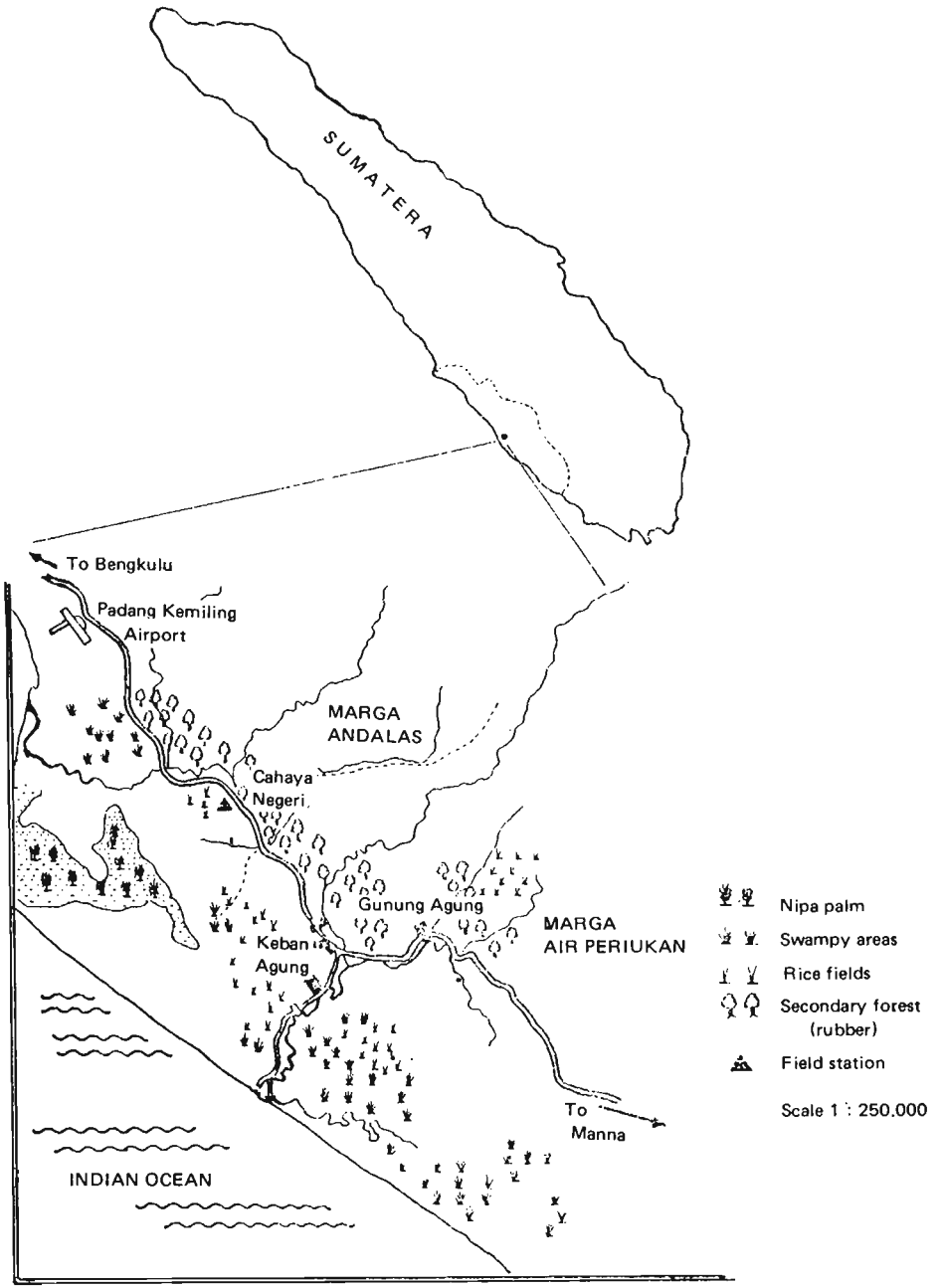

Fig. 1. Map showing study areas in South Bengkulu, Sumatera, Indonesia.

RESULTS

In Keban Agung a total of 11920 landing *Mansonia* mosquitoes from both indoors and outdoors were collected which comprised of 34.5% *Ma annulata*, 30.1% *Ma. bonneae*, 16.1% *Ma. dives* and 19.3% *Ma. uniformis*. Of 5421 *Mansonia* mosquitoes caught landing in Gunung Agung, 22.8% were *Ma. annulata*, 40.8% *Ma. bonneae*, 22.3% *Ma. dives* and 14.1% *Ma. uniformis*. Each species was slightly more exophagic than endophagic in both areas. Combining the four *Mansonia* species, 66.8% were cought landing outdoors in Keban Agung and 58.2% outdoors in Gunung Agung.

Studies on seasonal variations of *Mansonia* species compared with rainfall in Keban Agung (Fig. 2) show that the densities of *Ma. dives* and *Ma. annulata* were each significantly correlated ($\alpha = 0.6193$, $p < 0.01$; $\alpha = 0.4684$, $p < 0.05$), while no significant correlation was observed for *Ma. bonneae* and *Ma. uniformis* ($r = -0.1644$ and $r = -0.1882$). In Gunung Agung (Fig. 3), the density of each of the four *Mansonia* species was not significantly correlated with seasonal rainfall ($p > 0.05$).

In Keban Agung (Fig. 4) the parous rates of *Ma. annulata* (range : 1.30 – 60.0%) *Ma. bonneae* (5.6 – 70.0%), *Ma. dives* (18.7 – 71.4%) and *Ma. uniformis* (31.5 – 62.5%) were relatively low. Nevertheless, the parous rates of the former three species show significant negative correlation with rainfall (respectively $r = -0.4845$, $p < 0.02$; $r = -0.4437$, $p < 0.05$; $r = -0.4821$, $p < 0.02$), while no significant correlation was observed for *Ma. uniformis*

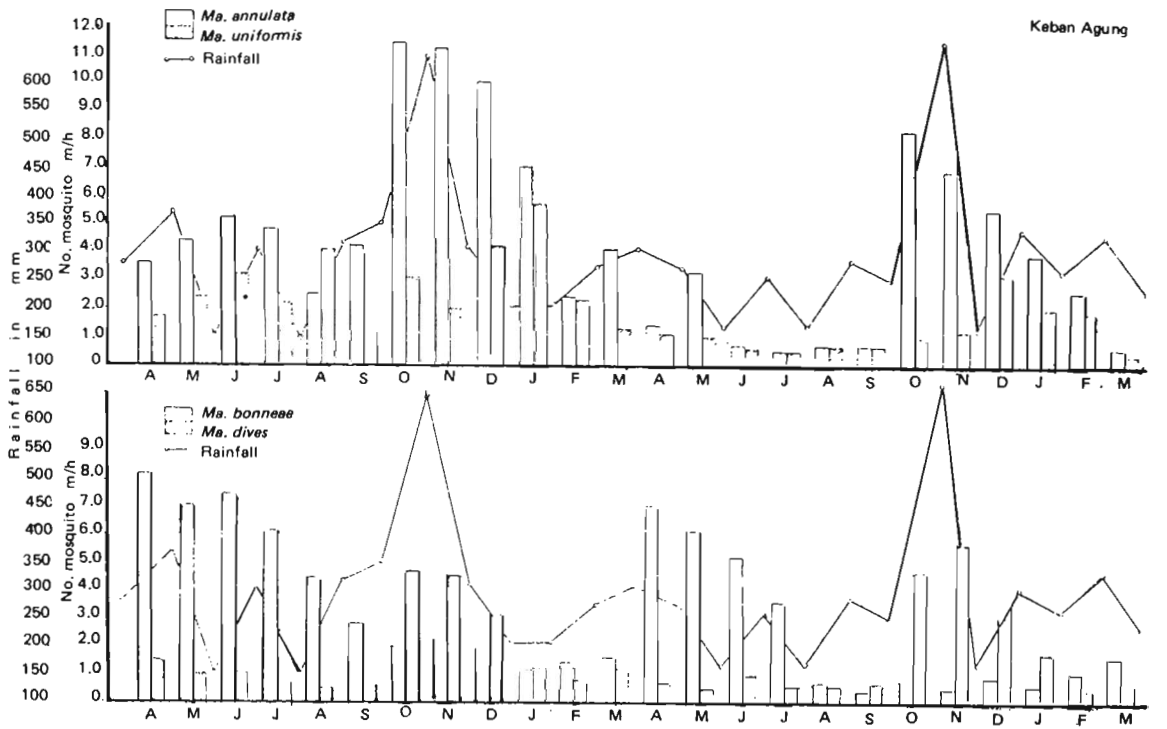

Fig. 2. Seasonal variation of four *Mansonia* species at Keban Agung, South Bengkulu, Sumatera, Indonesia.

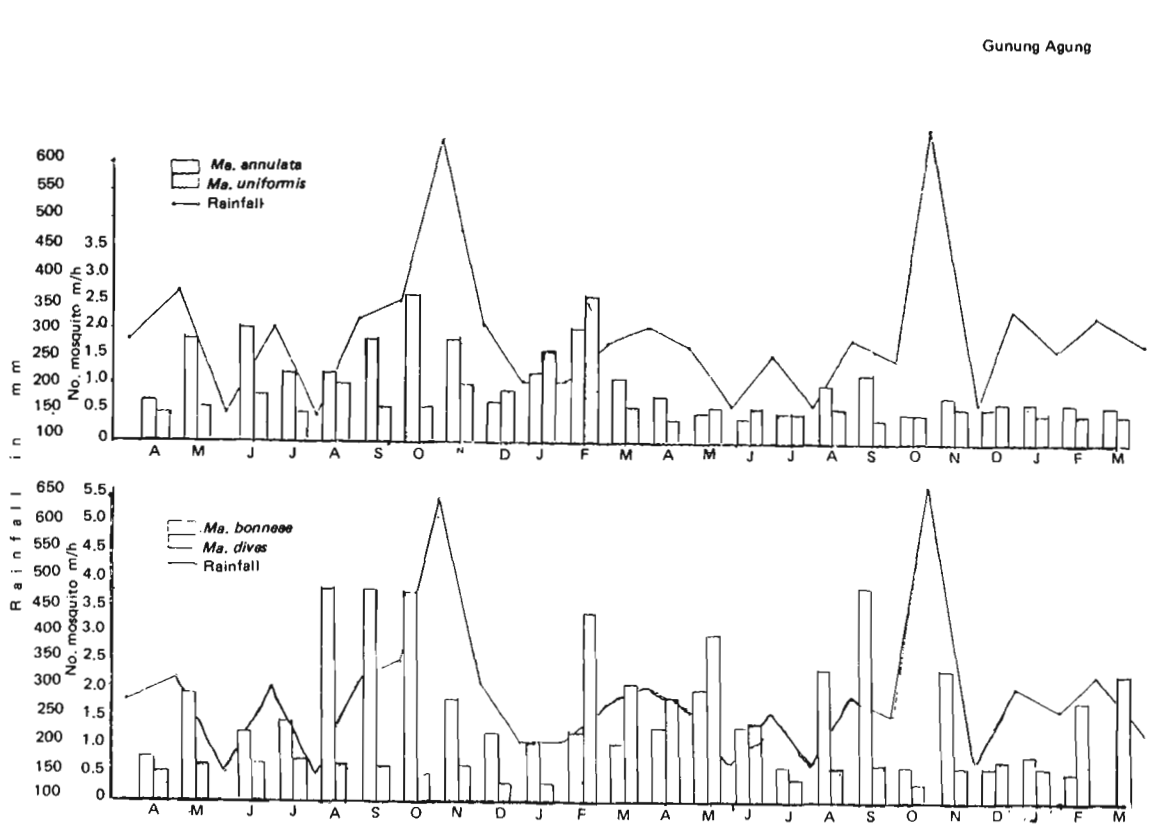

Fig. 3. Seasonal variation of four *Mansonia* species

(r = –0.0865). In Gunung Agung (Fig. 5) the parous rates of *Ma. annulata* (range: 21.6 – 59.1%), *Ma. bonneae* (7.9 – 63.6%), *Ma. dives* (20.0 – 86.7%) and *Ma. uniformis* (26.3 – 65.4%) were also low. However, significant negative correlation with rainfall was shown in *Ma. annulata* ($r = -0.5430$, $p < 0.01$), *Ma. bonneae* ($r = -0.5223$, $p < 0.01$), and *Ma. dives* ($r = -0.5480$, $p < 0.01$), but not so for *Ma. uniformis* (r = –0.0865).

The landing collections of each of the four *Mansonia* species from tree platforms were found to follow the same trend of vertical distribution in Keban Agung and Gunung Agung villages. As such the catches from both the areas were combined, and the results are presented in Fig. 6. A separate analysis of variance was run for each species in regards to the numbers caught at the various height (0, 5, 10 & 15 m) above ground over 24 catches. Each species showed a significant difference in the numbers caught at the different elevations, i.e. $p < 0.05$ for *Ma. annulata* and $p < 0.001$ for each of the other three species. The variance ratios for *Ma. bonneae* was 9.5819, for *Ma. dives* 12,1808, for *Ma. uniformis* 17,5701, and for *Ma. annulata* 2.983. The first two species were caught mostly at the higher levels, while the last two species were mostly caught closer to the ground.

The indoor biting activities for each of the four *Mansonia* species from the two areas were combined, and so was that from the outdoors, and the result is presented in Fig. 7.

Indoor biting cycles of *Ma. bonneae* and *Ma. dives* were very similar. The peak biting activities were between 18.00–20.00 hours, although more pronounced between 19.00–

20.00 hours. Little or no activity was shown from 23.00–02.00 hours, then they were active again with a lesser biting peak between 03.00 – 04.00 hours. *Ma. annulata* was active during the first two hours immediately after dusk, and subsequently declined through the morning. Two biting peaks were observed for *Ma. uniformis*, one immediately after dusk and one at midnight. No activity was observed between 01.00 – 02.00 hours, but activity began again to a lesser degree from 03.00 to 05.00 hours.

Outdoor peak activities of *Ma. bonneae* and *Ma. dives* were between 18.00 and 19.00 hours, and subsequently declined until a second lesser peak from 02.00 and 03.00 hours. The biting cycle of *Ma. annulata* was similar to that of the

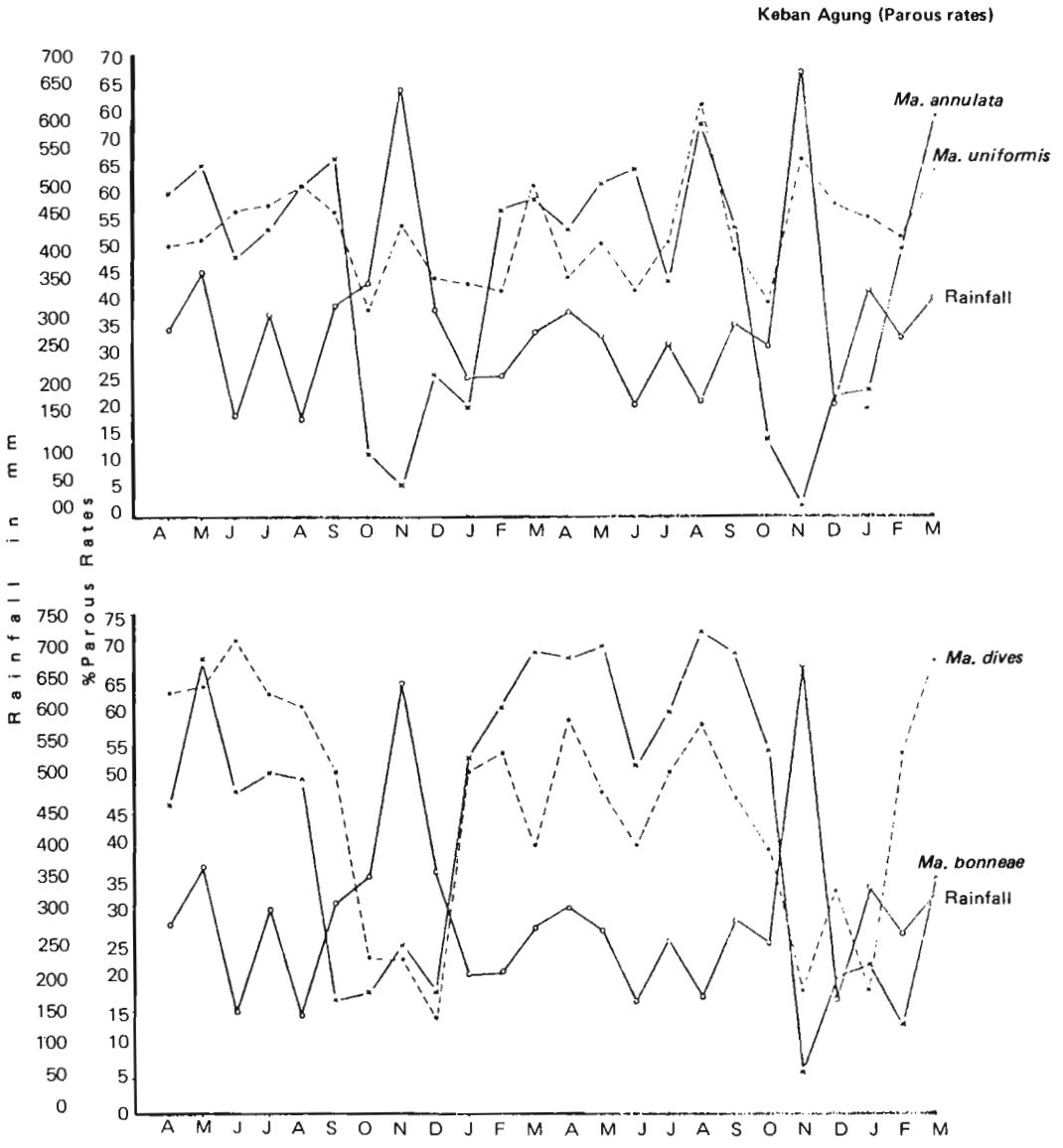

Fig.4. Seasonal parous rates of four *Mansonia* species at Keban Agung, South Bengkulu, Sumatera, Indonesia.

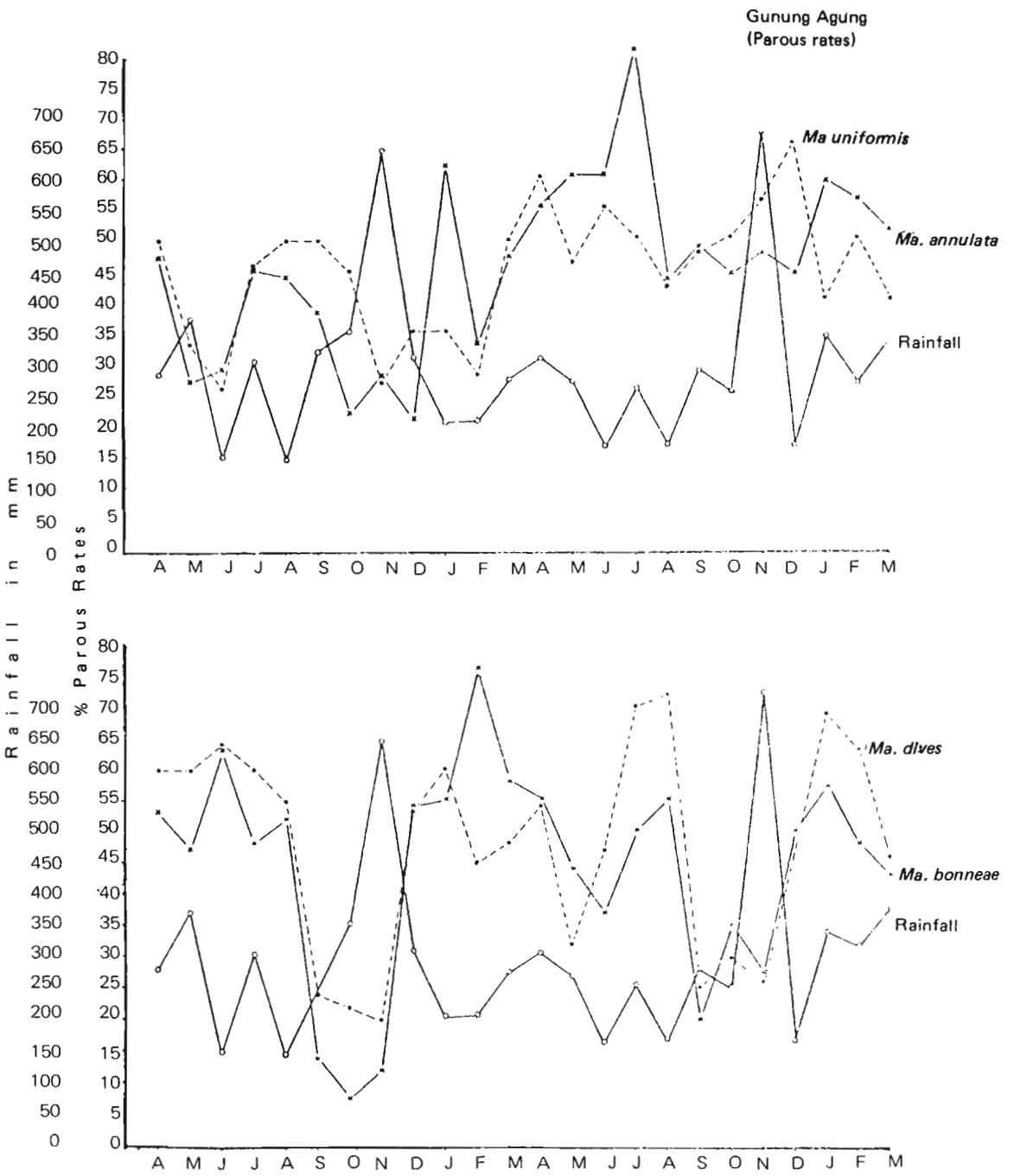

Fig. 5. Parous rates of four *Mansonia* species at Gunung Agung, South Bengkulu, Sumatera, Indonesia.

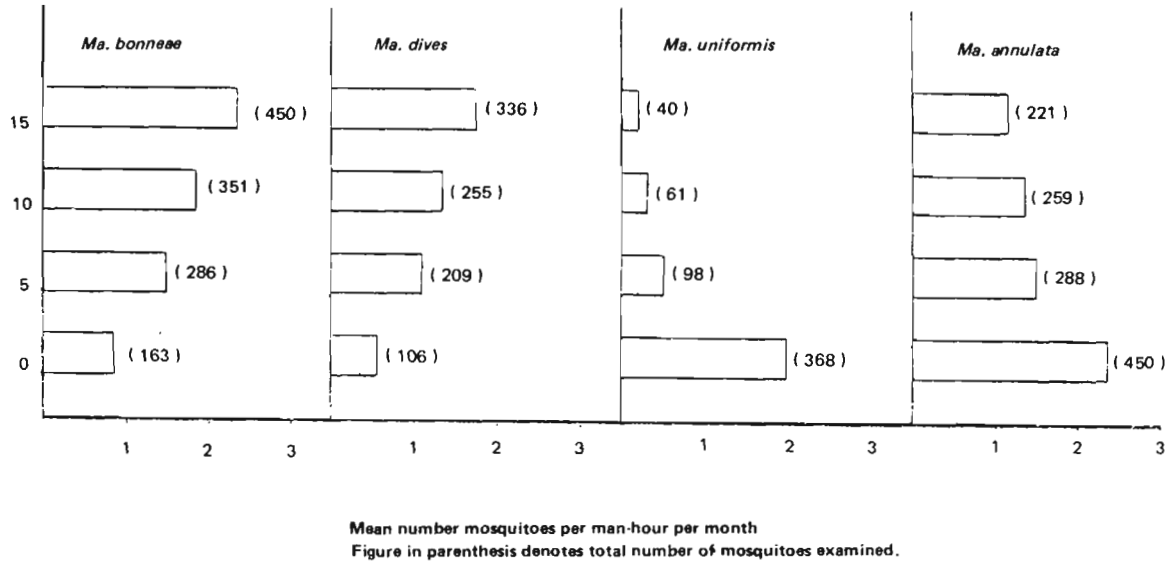

Fig. 6. Vertical distribution of four *Mansonia* species in the study areas, south Bengkulu, Sumatera, Indonesia.
(Figure in parenthesis denotes total catch in each elevation)

indoors, while *Ma. uniformis* was observed to bite throughout the night and morning hours, with peaks at 18.00–19.00 hours, a second peak between 03.00 to 05.00 hours, and a lesser third peak at midnight.

The results of the sampling of *Mansonia* larvae from both the villages are presented in Table 1. The number of larvae obtained from the sampling method was small, however, four basic biotypes of breeding place can be recognized.

1. Man-made open swamps which vary from one to five hectares in area near human settlements are common in Keban Agung village, but absent in Gunung Agung. These swamps are neglected, unused ricefields overgrown by swamp grass *(Isachne globasa* and *Panicum amplexicaule)* plus a variety of sedges and reeds. They become flooded during the heavy rainy periods. The four *Mansonia* species are produced in this type of habitat.

2. Man-made islands of nipah palms *(Nipa fruticans)* and varieties of weeds and reeds are common in both the villages. Some of these are dry during the dry season, and some are with pools of water all the year round. During heavy rain water on these islands is flushed out. In both the areas only *Ma. uniformis* larvae were found.

3. Man-made pools which vary from one to two meters in circumference, are used for water storage for irrigation of vegetable cultivation. These are more common in Gunung Agung than in Keban Agung. These pools have water hyacinth *(Eichornia crassipes),* water lettuce *(Pistia stratioites),* kangkung *(Ipomoea reptans),* and other water weeds and grasses. Most of the pools are filled with water all year. In Keban Agung larvae of all four *Mansonia* species, and in Gunung Agung 3 of the 4 *Mansonia* species were found.

4. Swamps at the fringe of the forest varying from 5 to 15 meters in length are more common in Gunung Agung than Keban Agung. The vegetation in such swamp areas is a variety of ferns, nipah palms, swamp grasses, Pneumatophores of the rattan *(Plectocoma griffithi)* plus dead palm stems and weeds. All the four *Mansonia* larval species breed in this habitat in Gunung Agung, while only 3 are in Keban Agung.

DISCUSSION

The four *Mansonia* species in the study areas

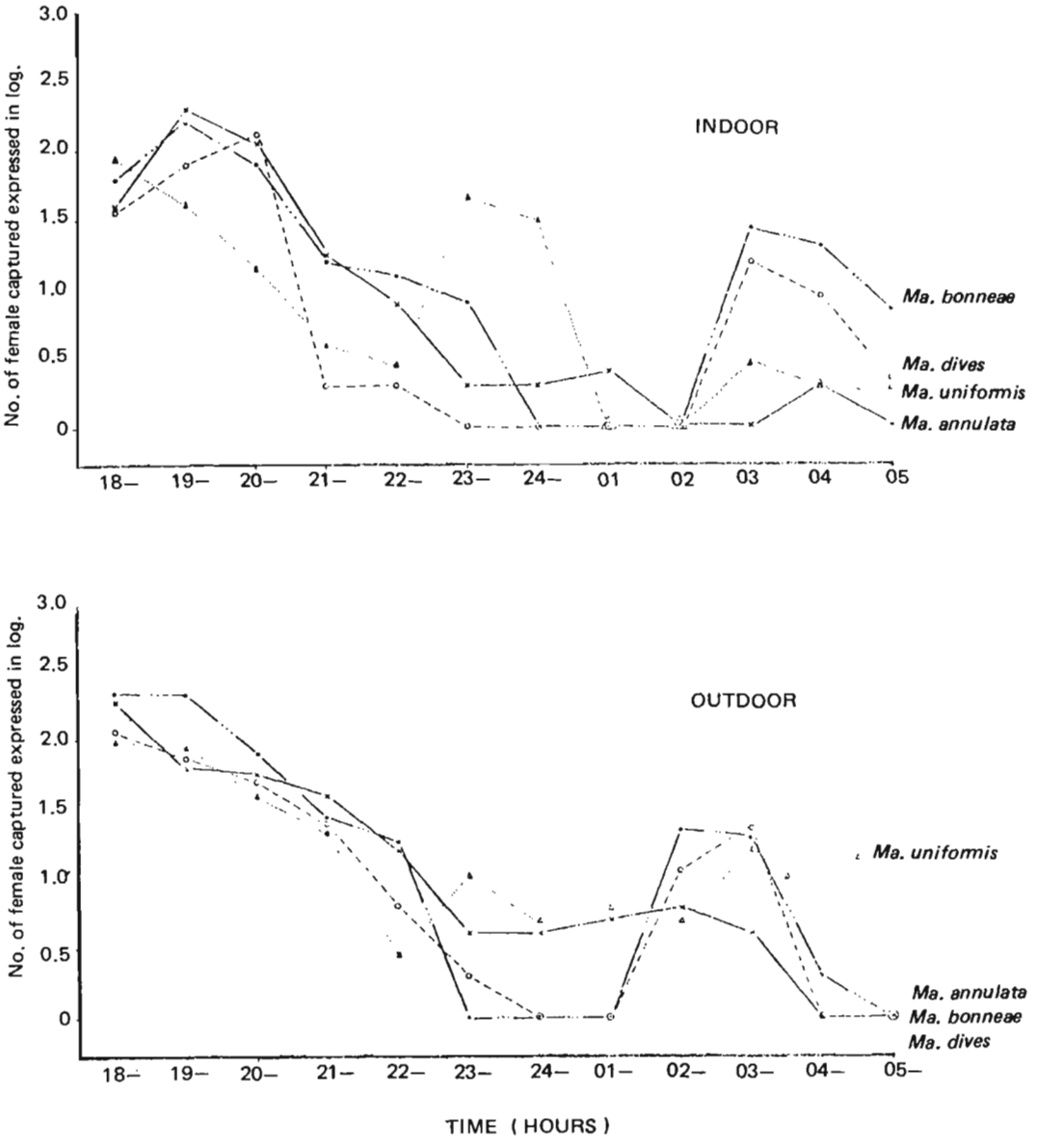

Fig. 7. Comparision of biting cycles on four *Mansonia* species between indoor and outdoor landing collections from south Bengkulu, Sumatera, Indonesia.

at South Sumatera revealed that the densities of *Ma. bonneae* and *Ma. annulata* were greater than *Ma. uniformis* and *Ma. dives.* The habitats where these mosquitoes bred were found mostly in artificially made environs with the exception of the forest fringe swamp. Most of these habitats were without water but still damp during the dry period, and the sustaining breeding cycles of these mosquitoes are not around the human settlements but probably in forest swamps. Wharton (1962) demonstrated that *Ma. dives* and *Ma. bonneae* were found in shaded pools well inside the forest, and *Ma. annulata* and *Ma. uniformis* were in open swamps beyond

Table 1. Larval surveys for *Mansonia* larvae in different habitats.

Biotypes	Keban Agung					Gunung Agung				
	Number of collection	*annulata*	*bonneae*	*dives*	*uniformis*	Number of collection	*annulata*	*bonneae*	*dives*	*uniformis*
Man-made open swamps	22	3	2	8	2	–	–	–	–	–
Man-made islands of nipah palms	28	–	–	–	7	29	–	–	–	3
Man-made pools	24	2	2	3	15	26	–	3	2	22
Forest-fringe swamps	30	4	11	5	–	25	3	8	18	8
	104	9	15	16	24	80	3	11	20	33

the forest. The present observations are not sufficiently extensive to work out indices of association between different species in these man made habitats.

Although the densities of adults vary from month to month, rainfall was not generally found to influence peak cycles of most of these mosquitoes with the exception of *Ma. dives* and *Ma. annulata* in Keban Agung village only. The facts that this relationship was not found for *Ma. bonneae* and *Ma. uniformis* in the same village, and that in Gunung Agung none of the four species were found correlated with rainfall, suggest that the correlation of densities with rainfall of *Ma. dives* and *Ma. annulata* in Keban Agung may have been by chance. However, it was noted more mature adults of these *Mansonia* species were observed during the drier period of the year. Wharton (1962) found that rainfall does not effect the breeding places of *Mansonia* species in Malaysia as the habitats where they breed never dry out completely. However, in Ceylon the onset of heavy rain promotes the growth of aquatic grasses in the paddy fields and leads to the increase in the population of *Ma. uniformis* (Antoni Pulle, David and Karunaratre, 1958). Although similar habitats like that in Ceylon are found in these study areas, but the adult population of this species did not exhibit such a pattern in the present study.

The biting activities of these mosquitoes appeared to have some differences between indoors and outdoors. Inside the house evening and morning biting peaks were shown for *Ma. bonneae* and *Ma. dives* as compared to only one evening peak observed outdoors, and a single evening peak was shown for *Ma. annulata* both indoors and outdoors. *Ma. uniformis* appears to be the most active one with three indoor peaks, evening, midnight and morning. Outdoors this mosquito was active throughout the evening through morning hours with one evening and one morning peak. In mangroves forest in Malaysia, Wharton (1962) found *Ma. bonneae*, Ma. dives and *Ma. uniformis* were mainly nocturnal feeders, the biting peak of these mosquitoes outside occured between 18.00 and 19.00 hours, and inside houses at 18.00 hours, but continued through the night with another biting peak around midnight.

The behaviour of the four *Mansonia* species show that *Ma. bonneae* and *Ma. dives* are similar in their activity pattern, while that of *Ma. uniformis* and *Ma. annulata* exhibit some differences from the former two species. In addition, it was also found that in the vertical distribution, greater numbers of the former two species were caught at higher elevation, while the reverse was shown in the latter two species. The fact that they are also found to adapt themselves to higher elevation, and their preference of forest-fringe swamp in addition to surrounding habitats around human settlements, suggest that these

two species are more widely dispersed than the others. As all these species were shown to be natural vectors of periodic *B. malayi* in the study areas (Suzuki et al., 1981), and *Ma. bonneae* and *Ma. dives* being more efficient vectors (Sudomo & Lim – in manuscript), it may be concluded that both these species probably maintained a higher rate of transmission in the settlement than the other two species.

In the present study on the behaviour and ecology of these mosquitoes, though there are still many gaps to be filled, nevertheless, it provides some aspects of adult behaviour of these four *Mansonia* species which are little known in Indonesia.

SUMMARY

Studies on four *Mansonia* species in two villages in South Bengkulu, revealed that *Ma. bonneae* and *Ma. annulata* were more common than *Ma. dives* and *Ma. uniformis* in each of the villages. There were also more of the former two species caught outdoors than indoors. The habitats of these mosquitoes were mostly in man-made swamps and forest fringe swamps. In Keban Agung the densities of *Ma. dives* and *Ma. annulata* were each found to be significantly correlated with rainfall, and not so for the other two species, but in Gunung Agung densities of all the four *Mansonia* species were not found to be correlated with rainfall. The parous rates of 3 of the 4 *Mansonia* species were found to be negatively correlated with rainfall. Vertical distribution showed that greater numbers of *Ma. bonneae* and *Ma. dives* were caught at higher than lower elevations, while the reverse was found for *Ma. uniformis* and *Ma. annulata.* Two biting peaks for *Ma. bonneae* and *Ma. dives,* three for *Ma. uniformis* and one for *Ma. annulata* were observed during 12 hour landing collections.

ACKNOWLEDGEMENT

The authors are grateful to the field staff, National Institute of Health Research and Development (NIHRD), Jakarta, and also to Dr. E. Oswari, Director of Health Services, Bengkulu and Dr. Abu Hanifah, Chief, CDC, Bengkulu, for their supports. Thanks are also due to Dr. N.G. Gratz, Director, VBC, Geneva, and Dr. C.P. Pant, Chief, ECV, Geneva for their criticisms, Dr. Y.H. Bang, Project Leader, VBCRU-2, Jakarta for his support, and Mr. H.L. Mathis for his assistance in the statistical analysis of the data.

REFERENCES

Antoni Pulle, P.V., H.V. David, and M.D.R. Karunaratre, (1958) Biology and control of *Taeniorhynchus (Mansonioides) uniformis* Theobald, the chief vector of rural filariasis in Ceylon. *Bull. Wld. Hlth. Org.,* 19 : 285.

Gillett, J.D. (1946) Notes on the subgenus *Coquillettidia* Dyar (Diptera, Culicidae). *Bull. Cat. Res.,* 36 : 1425.

Sudomo, M., Suwarto and Lim Boo Liat (1983) Studies of filariasis in Keban Agung and Gunung Agung villages in South Bengkulu, Sumatera, Indonesia : I. The Mosquito Fauna with reference to seasonal studies of two *Anopheles* and *Culex tritaeniorhynchus* Bull Health Studies in Indonesia, XI. 1 : 25–35.

Suzuki, T., M. Sudomo, Y.H. Bang and Lim Boo Liat (1981) Studies on malayan filariasis in Bengkulu (Sumatera), Indonesia with special reference to vector confirmation. *Southeast Asian J. Trop. Med. Publ. Hlth.* 12 : 47.

Wharton, R.H. (1982) The biology of *Mansonia* mosquitoes in relation to the transmission of filariasis in Malaya. *Institute Medical Research, Bulletin* No. 11, 114 pp. Revised in 1978.